Space Weather Technical Forecast

Issued on Saturday, 12 March 2022 at 01:09 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Geomagnetic activity expected to increase days 2 and 3, with a G1/Minor geomagnetic storm likely. Chance of further M-Class flares.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the past 24 hours, with an M2.3 flare at 11/2232 UTC and several C-class flares observed. These originating mostly from AR2964 in the southwest and AR2965 in the northeast. The long period C2.8 flare from 10th March emitted a large and wide, full halo CME, which is expected to hit Earth either late on 13th March or early on 14th March. Further imagery is necessary before any ejecta can be identified from the M2.3 flare from late on 11th.

There are five sunspot regions on the visible disc, with AR2965 the largest and also magnetically complex. There are also two other large groups, AR2960 and AR2964. The latter of which is where the M2.3 flare occurred late on 11th. The remaining sunspots on the visible disc are small, weak and magnetically simple.

There are also numerous - mostly small - filaments on the disc at present. The largest of these lifted off the southeastern limb late in the UTC evening of 09 March, with the resultant Coronal Mass Ejection (CME) clearly discernible in coronagraphs. A marginal influence is possible at Earth from at least the shock either late 13th March or more likely through 14th March.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR at L1, was mostly at background levels initially, rising to slightly elevated from 11/0800 UTC, with a peak of 423km/s at 11/2229 UTC. The solar wind density was predominantly at average levels, but with some periods of above average density during the first 12 hours, with a maximum of 20ppcc observed around 11/1200 UTC. The IMF was largely Moderate with a maximum of 14nT observed twice, once at the very start of the period and once around 11/1100 UTC. The north-south component fluctuating wildly between weak and moderate throughout and in both positive and negative directions of +11/-10 nT. The phi angle was largely negative (toward the sun), with with brief spells of positive (away from the sun) orientations. These parameter fluctuations are implicit of the after effects of the CME arrivals from the 5th and 7th March. Geomagnetic activity was initially Active (Kp 4) but gradually became Quiet to Unsettled (Kp 2-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) measured at GOES 16 was slightly above background levels in response to the CME being emitted from the long period C-class flare from 10th, but remained below the S1 level.

The high energy electron flux (greater than 2 MeV) was Background to Moderate levels, with the corresponding 24-hour integrated electron fluence dipping below the Active (1e8 integrated pfu) level from 11/1500 UTC after a sustained period above over recent days. 2.64e6 integrated pfu was observed at 12/0000 UTC.

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Met Office Space Weather Technical Forecast

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Low to Moderate, with further C-class flares expected and a chance of further M-class flares. The risk being distributed between AR2965 and AR2964, though risks reducing marginally on day 3 as AR2954 rotates out of view and past the west limb.

Solar Wind / Geomagnetic Activity: There are two potentially Earth-directed CME's in the forecast. The first is from the 9th March southeast quadrant filament. This may influence Earth either late day 2 (13th) or through day 3 (14th). Yesterday's large full halo CME has been analysed and is Earth-directed, and is also expected to arrive either late on day 2 (13th) or early on day 3 (14th), and will probably be a larger impact than the 9th March CME. Meanwhile, CH65/- in the west may bring fast wind during day 2 (13th), although this is likely to be absorbed by the large CME, which may also enhance geomagnetic activity.

Geomagnetic activity is expected to trend back to mostly Quiet or Unsettled (Kp1-3) conditions, with a slight chance of further Active or G1/Minor Storm intervals. During day 2 (13th) activity is likely to increase, becoming generally Unsettled to Active, either under the influence of the 9th March CME, but more likely due to the expected arrival of yesterday's full halo CME. This is likely to give a G1/Minor (Kp 5) Storm late on day 2 or during day 3 (13th or 14th), with a Chance of a G2/Moderate (Kp 6). Geomagnetic activity will then return to largely Quiet to Unsettled (Kp 1-3) from day 4, with only a slight chance of Active or G1/Minor storm intervals.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain predominantly at Background levels, albeit with a very slight chance of rising above-the S1 level.

The high energy (greater than 2 MeV) electron flux is currently at Background to Moderate levels, but there is a chance of a rebound day 1 (12th), especially at the peak of the diurnal cycles. During days 2 and 3 (13th and 14th), with the likely increase in geomagnetic activity, the electron flux is expected to decrease to background to moderate levels. There is a chance during day 4 (15th) electron flux may become active again.

The corresponding fluence will be below the Active levels (1e8 integrated flux) with only a slight chance of increasing above Active levels, mainly day 1 (12th).

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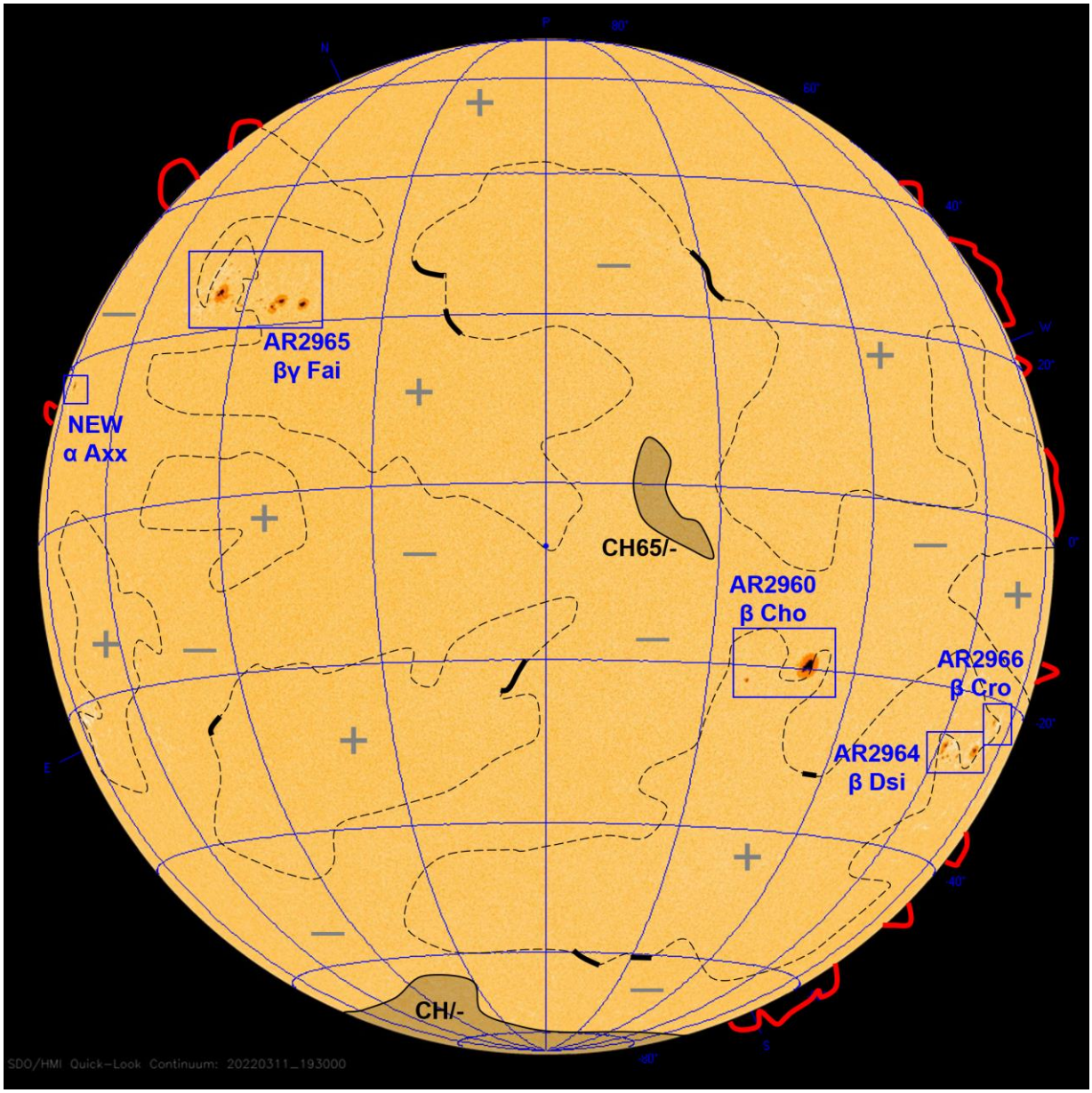
Figure 1. Solar Analysis Valid 11/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are two potentially Earth-directed CME's in the forecast. The first is from the 9th March southeast quadrant filament. This may influence Earth either late day 2 (13th) or through day 3 (14th). Yesterday's large full halo CME has been analysed and is Earth-directed, and is also expected to arrive either late on day 2 (13th) or early on day 3 (14th), and will probably be a larger impact than the 9th March CME. Meanwhile, CH65/- in the west may bring fast wind during day 2 (13th), although this is likely to be absorbed by the large CME, which may also enhance geomagnetic activity. The combination of the arrival of the two CME's and the HSS late on 13th or early 14th is bringing the higher than average risks as displayed in the table above. Day 4 (15th) will then likely see solar winds speeds return to slightly elevated or background levels.

Geomagnetic activity is expected to trend back to mostly Quiet or Unsettled (Kp1-3) conditions during day 1, with a chance of further Active or G1/Minor Storm intervals. During day 2 (13th) activity is likely to increase, becoming generally Unsettled to Active, either under the influence of the 9th March CME, but more likely due to the expected arrival of yesterday's full halo CME. This is likely to give a G1/Minor (Kp 5) Storm late on day 2 or during day 3 (13th or 14th), with a Chance of a G2/Moderate (Kp 6). Geomagnetic activity will then return to largely Quiet to Unsettled (Kp 1-3) from day 4, with only a slight chance of Active or G1/Minor storm intervals.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	30	70	60	10
Strong	G3	No	1	2	2	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
09/2300	Partial?	SE quadrant filament	36E 18S	445km/s	13/2300UTC	Possible shock, mainly outside period. Low
11/04:06	Full	NW quadrant	Approx 11W 23N	577	13/2200UTC (+/- 6hours)	Earth-directed

Figure 2: Clear Halo CME seen from LASCO C3 at 11/0130 UTC

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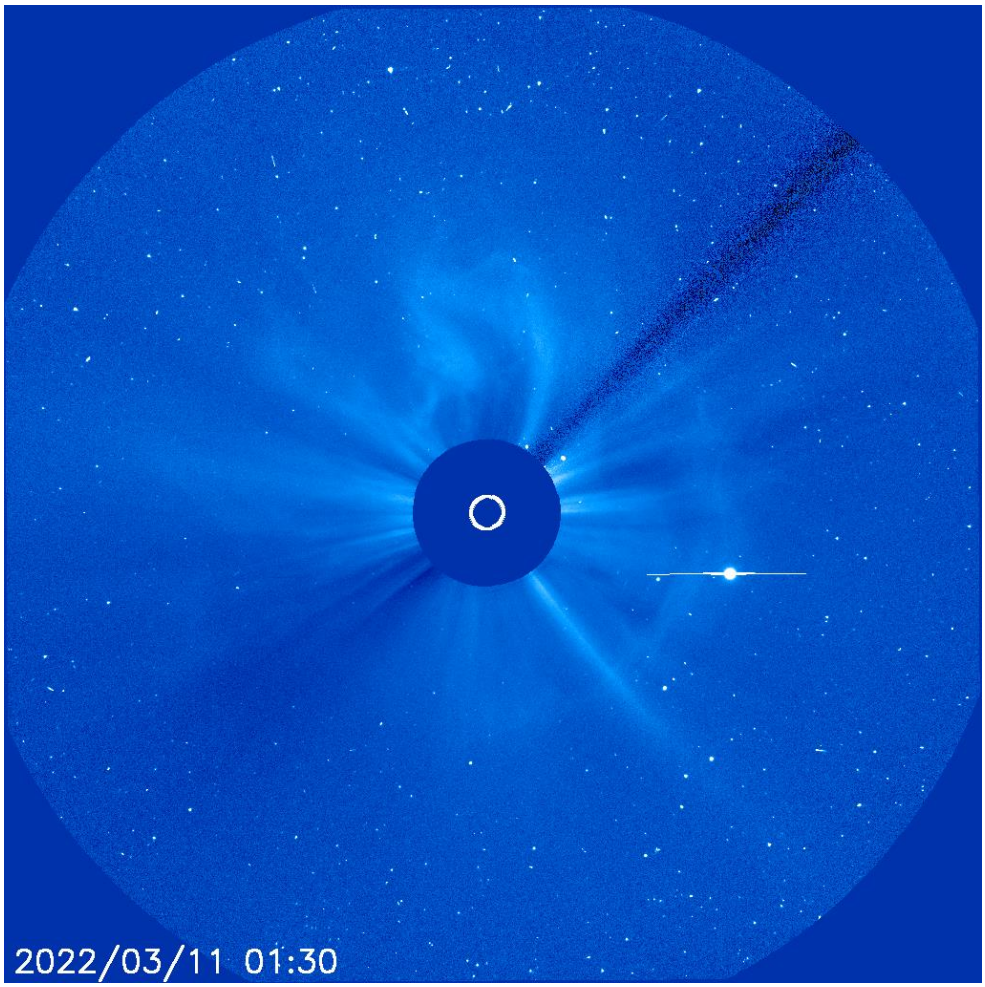

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Radio Blackouts - X-Ray Flares:

There are five sunspot regions on the visible disk and several small pores. AR2964 and AR2966 in the southwest are hard to discern between as they approach the western limb. The more complex of these two (2964) is more active and as a result emitted an M-class flare late on 11th. Further imagery is necessary before any CME evidence can be seen. Any results will be added in future forecasts.

AR2965 in the northwest is by far the most complex and largest but has only produced C-class flared in the past 24 hours. This region will be closely monitored and is partly the reason for the elevated M-class flares risk in the forecast above. From day 3 this will be the only region possibly producing M-class flares as AR2964 rotates around the western limb and out of sight, therefore the M-class flare risk likely reducing.

AR2960 is continuing to simplify but remains a large but stable region. All other small spots/pores are simple and pose very little risk to this forecast period at present.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	No	40	40	20	20
Very Active	R3 to R5 X Class	No	2	2	1	1

Figure 3: Xray flux trace past 24 hours.

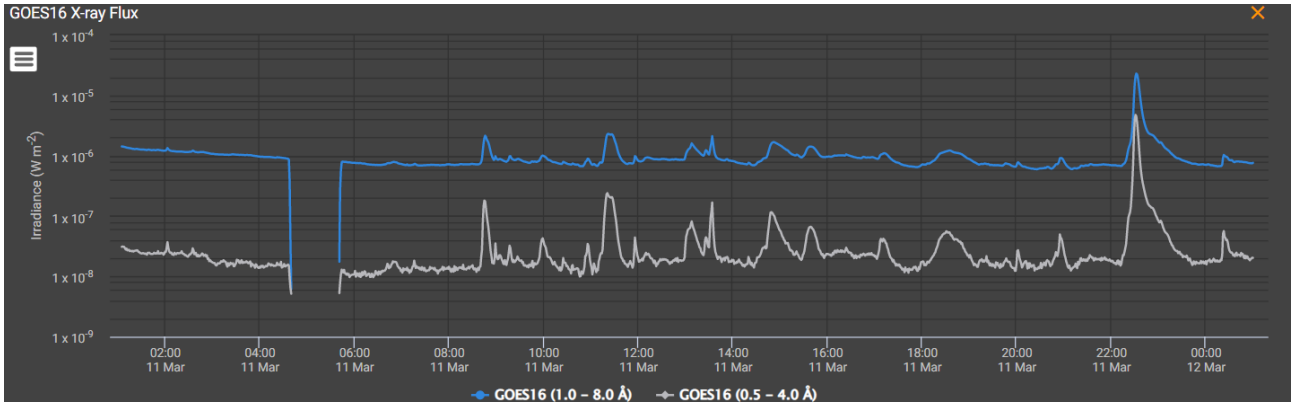

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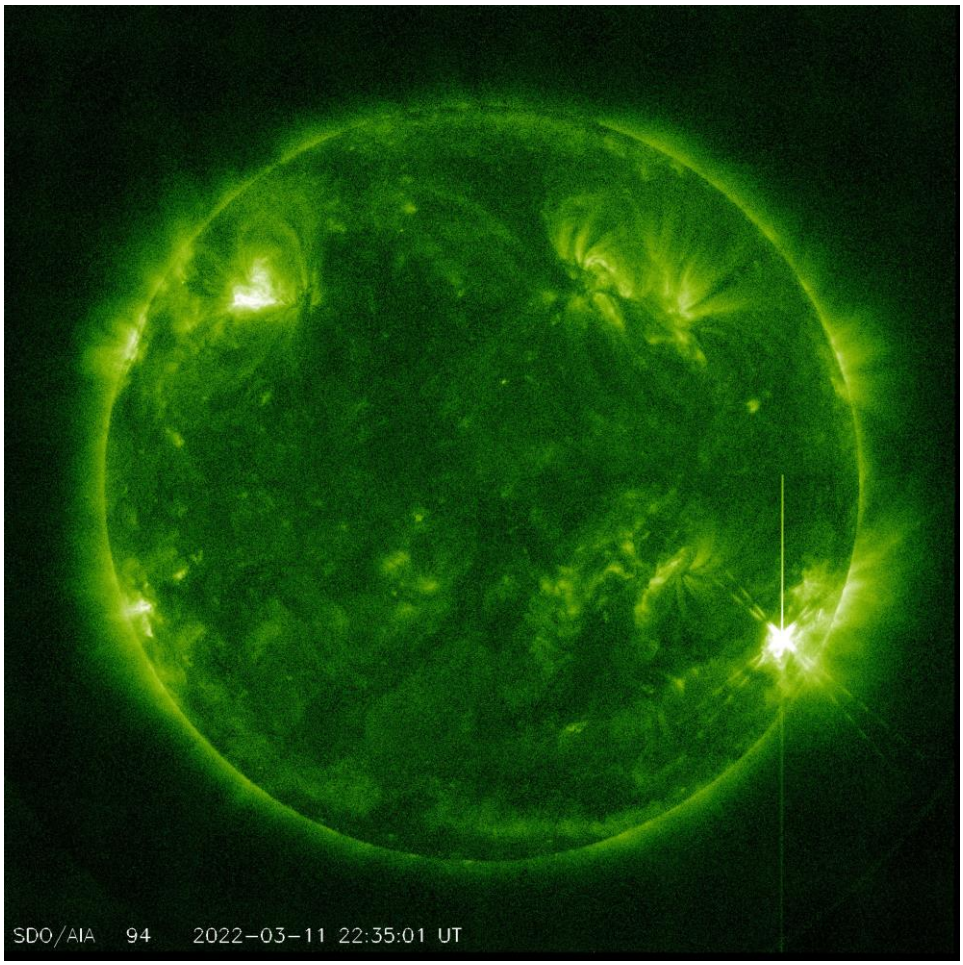
Figure 4: M-class flare from AR2964 on 11th March.



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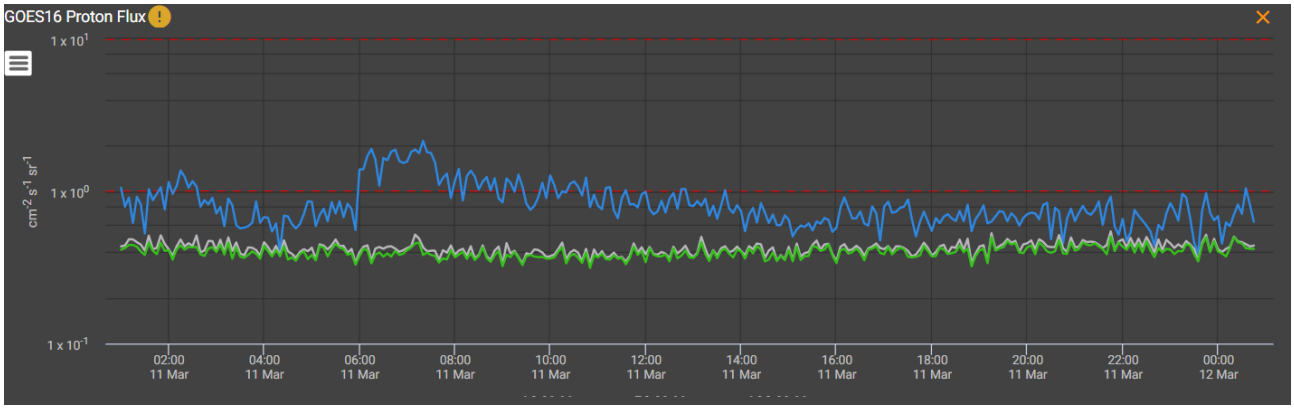
Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (10MeV) measured at GOES 16 is currently slightly elevated, under the residual influence of the CME that was emitted yesterday evening. The high energy proton flux is expected to return and then remain predominantly at background levels, albeit with a slight chance of rising above-the S1 level.

The probabilities have been increased very slightly to reflect the potential of a further large CME, either from the northwest quadrant again or from one of the large and complex sunspot regions on the disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 5: Proton flux as observed at GOES16.



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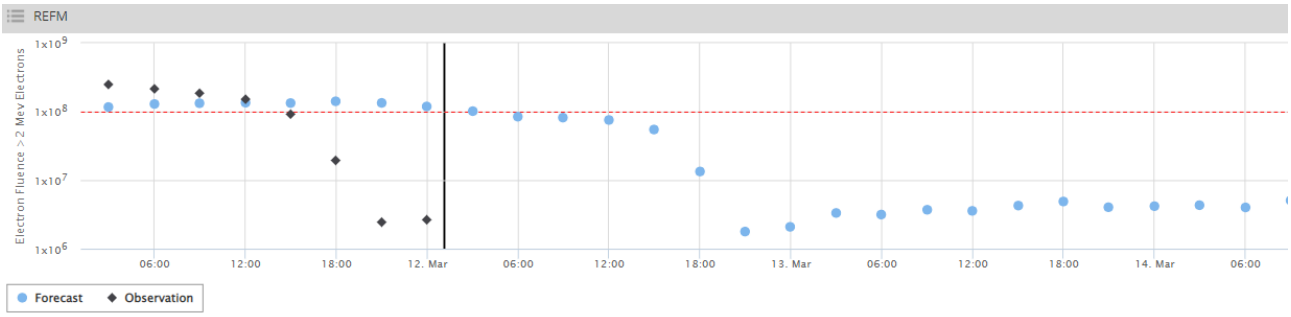
High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux is currently at Background to Moderate levels, but there is a chance of a rebound day 1 (12th), especially at the peak of the diurnal cycles. During days 2 and 3 (13th and 14th), with the likely increase in geomagnetic activity, the electron flux is expected to decrease to background to moderate levels. There is a chance during day 4 (15th) electron flux may become active again.

The corresponding fluence will be below the Active levels (1e8 integrated flux) with only a slight chance of increasing above Active levels, mainly day 1 (12th).

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	Yes	30	20	10	20
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 6: REFM fluence observations and forecast.



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